University of Victoria · UNIVERSIDAD ICESI

CAS Project ID #1068

DRISO Desarrollo e Ingeniería de Software · Rigi Research

DESIGNING RUN-TIME EVOLUTION FOR DEPENDABLE AND RESILIENT CYBER-PHYSICAL SYSTEMS USING DIGITAL TWINS

MASIVO INTEGRADO DE OCCIDENTE

- The operational plan is designed to last several months: fleet size, bus frequency, etc.
- Unexpected events are common
- Buses constantly report sensor data
- New sensors are added over time

455,000 Users per day

98 Bus lines

100s Bus stops

97% City's spatial perimeter

➤ PROBLEM

Users would like to wait less at stops and have more consistent timings

- Lower waiting times entail a higher cost of operation and more frequent bus maintenance
- Many factors external to the transportation system have a high impact on the buses' frequency and overall travel time

The operational plan is very complex and hard to change in the short term

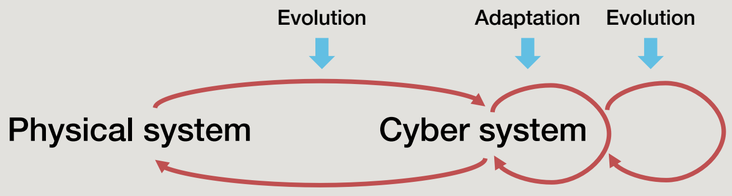
- Small and local changes to the operational plan may have a high impact on the overall system performance
- The operational plan is usually tweaked according to changes in the user demand over prolonged periods of time

➤ SOLUTION

SELF-ADAPTATION VS SELF-EVOLUTION

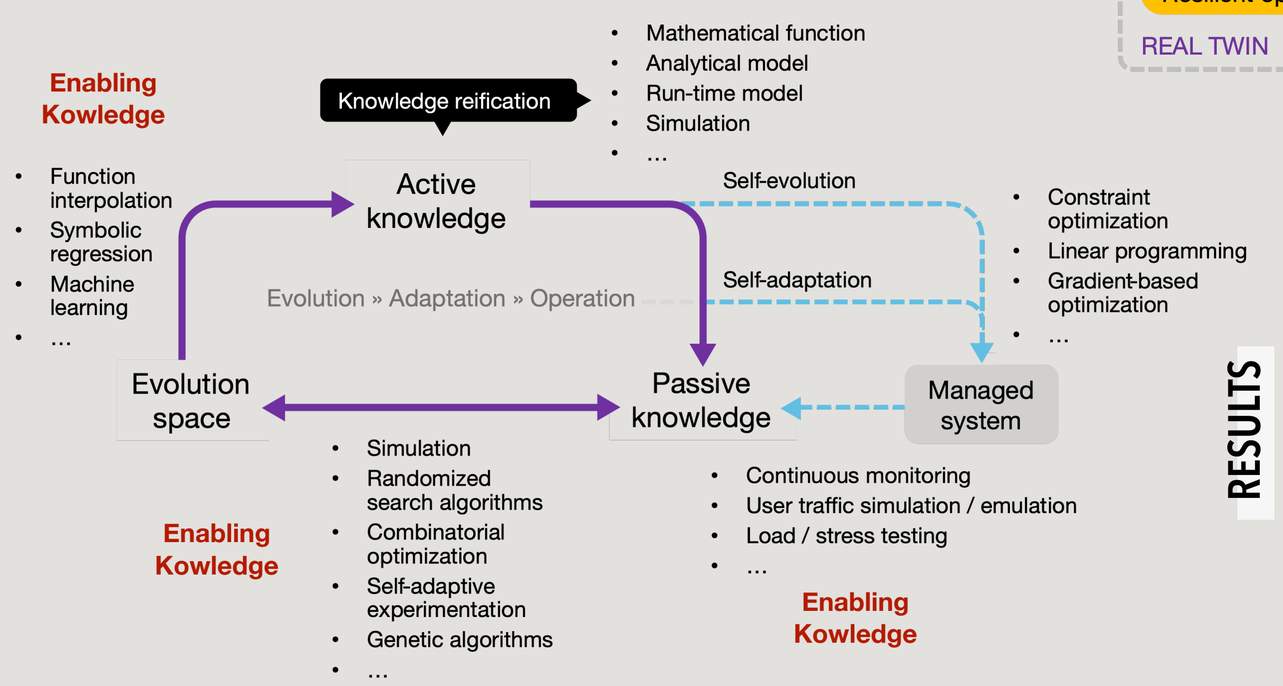
Two operational modes of an autonomic manager

- **Evolution from a Software Engineering perspective**: Evolution refers to changing the software system —producing a new version.
- **Evolution from a control perspective:** Evolution refers to changing the adaptation mechanism.
- **Adaptation:** Change the system's behavior.



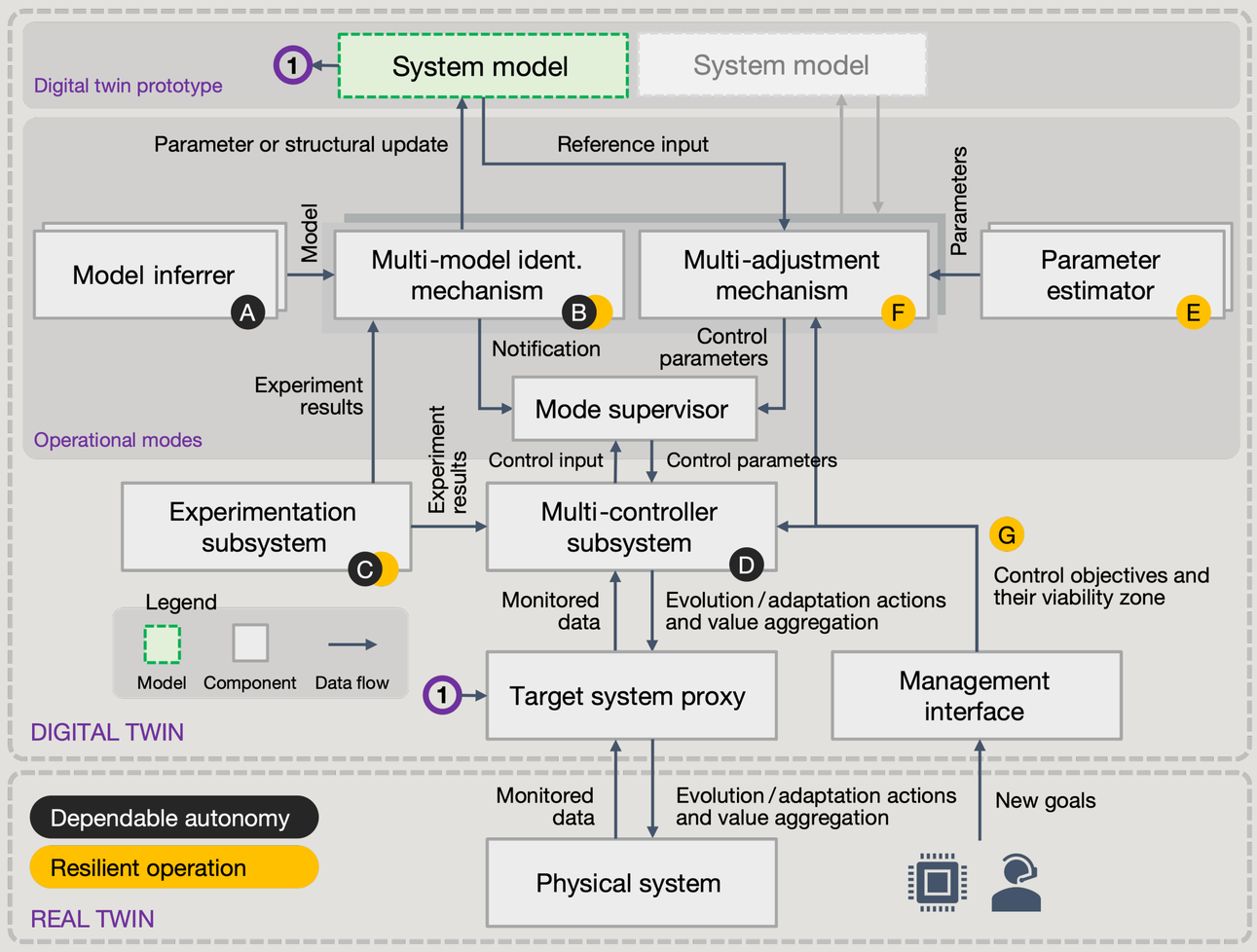
KNOWLEDGE DEVELOPMENT

Engineering cycle to reify knowledge at run-time



REFERENCE ARCHITECTURE

Architectural drivers: dependable autonomy and resilient operation



RESULTS

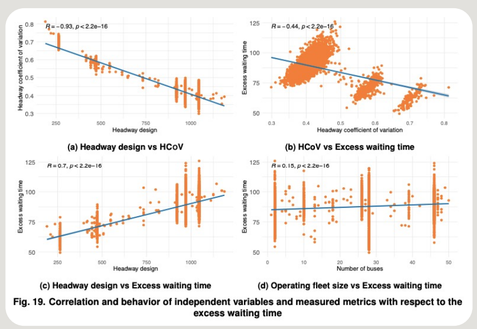


Fig. 19. Correlation and behavior of independent variables and measured metrics with respect to the excess waiting time

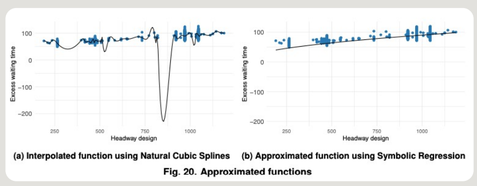


Fig. 20. Approximated functions

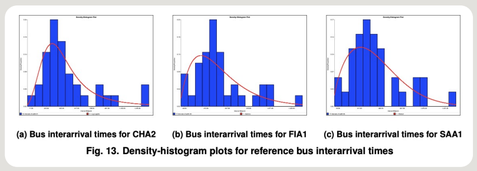


Fig. 13. Density-histogram plots for reference bus interarrival times

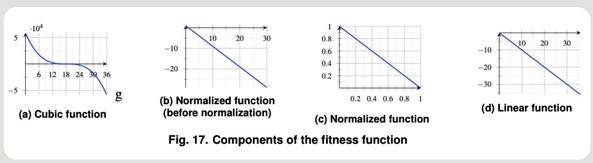


Fig. 17. Components of the fitness function

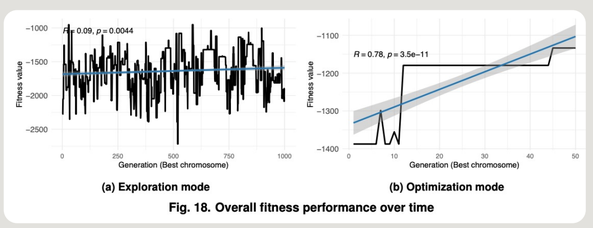


Fig. 18. Overall fitness performance over time

L. F. Rivera, M. Jiménez *et al*. **Designing Run-time Evolution for Dependable and Resilient Cyber-Physical Systems Using Digital Twins**, 2021 (in print)

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